Exploring the photometric variability of ultra-cool dwarfs

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Abstract

Ultra-cool dwarfs (UCDs) are objects with **effective temperatures below 3000 ºK** that include fully-convective very-low mass stars and brown dwarfs (Kirkpatrick et al. 1995, Bolmont et al. 2017). These faint objects mainly emit in the near-infrared and, thus, it is very difficult to perform photometric stellar activity studies using optical ground-based telescopes with limited observation times. However, the **Transiting Exoplanet Survey Satellite (TESS**; Ricker et al. 2015**) offers a unique opportunity to describe and quantify the optical flare rates and variability of these targets through high-precision photometry in order to understand the mechanisms involved in the generation of such intrinsic activity**. Hence, in this contribution, we present preliminary results of a search for flares and rotation periods in a sample of UCDs observed in 2-minutes cadence with the space mission TESS.

1- Targets and Observations

The UCD sample presented in this contribution is composed of **67 objects** of both hemispheres with spectral types (SpT) **from M4 to L2.** They were observed by the **space mission TESS** in different sectors (from 2 to 26) with a **2-minutes cadence**.

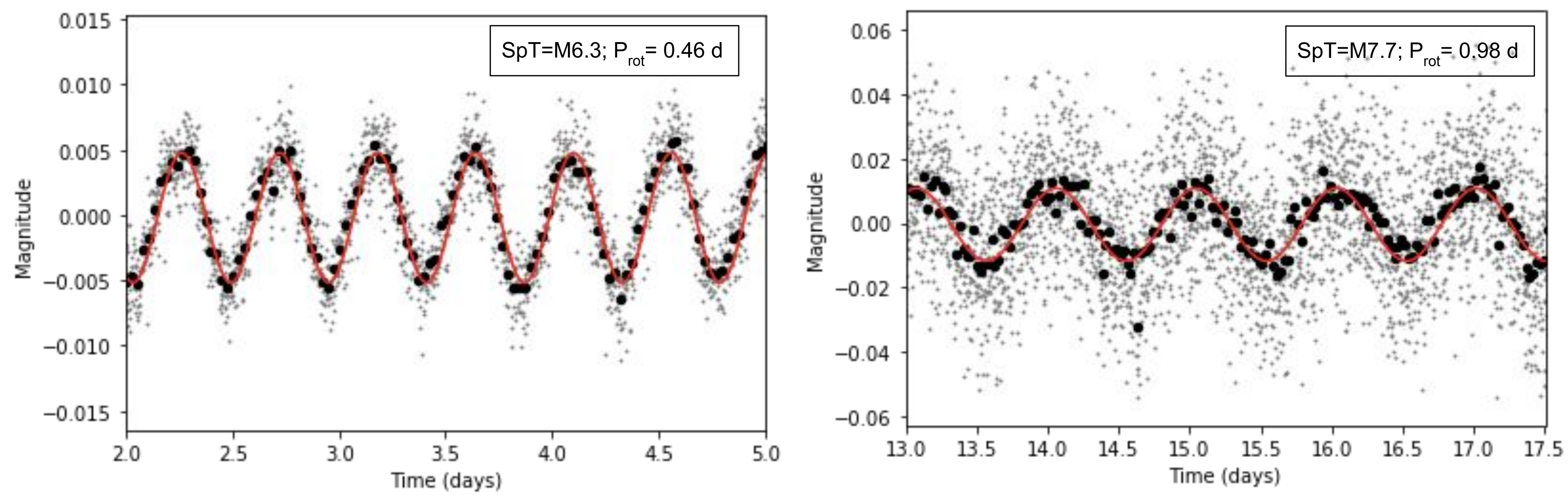

Figure 1: UCDs with sinusoidal modulations. Gray and black symbols are the binned and unbinned PDCSAP magnitudes, respectively, while the solid red lines represent the best fit to the photometric data. Spectral type and rotation period are indicated.

2- Flares and variability

We searched for signs of intrinsic activity in the PDCSAP photometric data, processed with the TESS SPOC pipeline (Jenkins et al. 2016). For each UCD, we used the *Altaipony* (Davenport 2016) code for flares detection, the Lomb-Scargle periodogram (Scargle 1982) provided by the *Lightkurve* Python package (Lightkurve Collaboration et al. 2018) and the Auto-Correlation Function (ACF; McQuillan et al. 2013) to find significant peaks that might indicate periodic sinusoidal modulations. In Figure 1, **we show some examples of sinusoidal modulations found in the sample of UCDs analyzed in this work.**

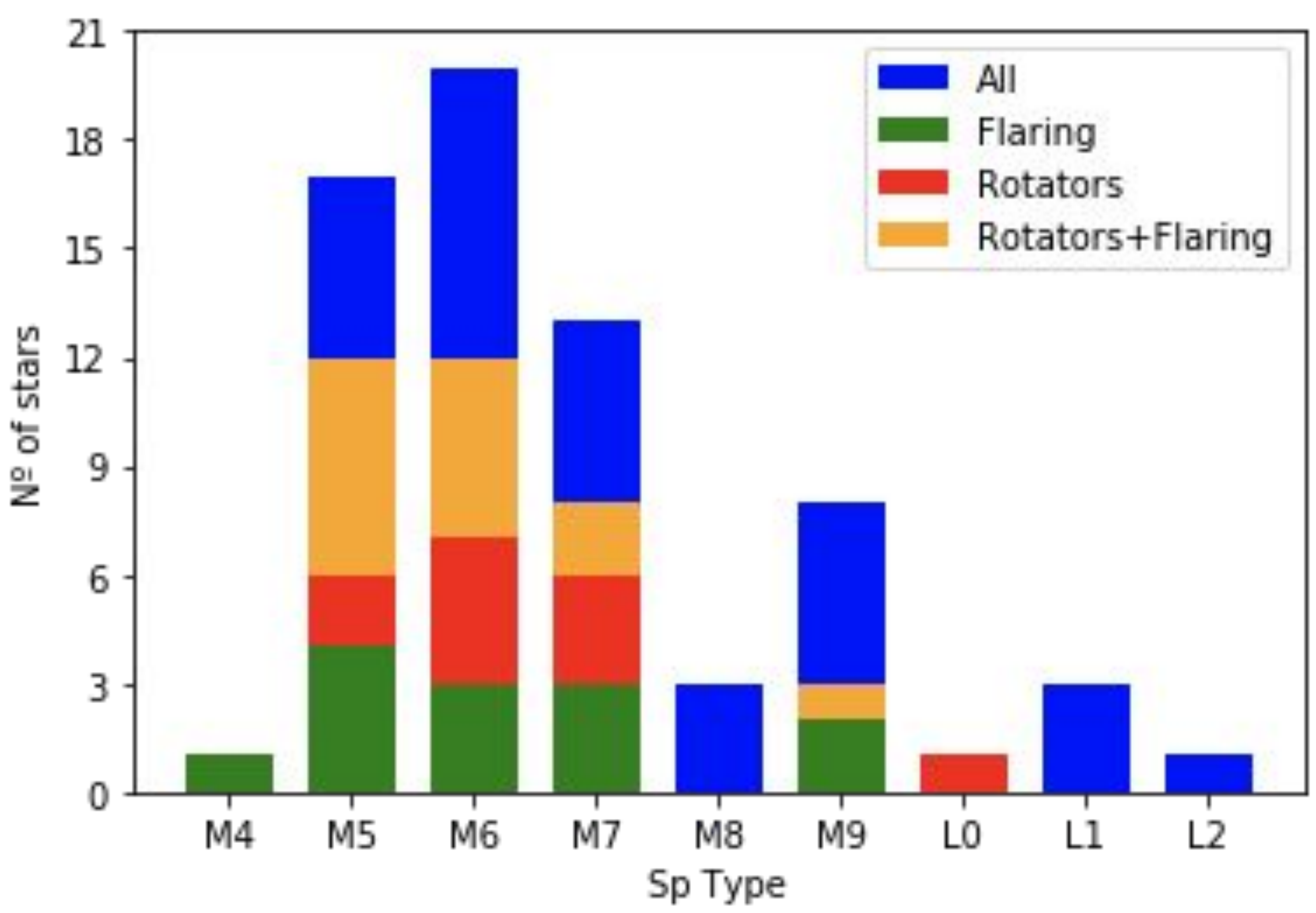

Figure 2: Histograms of the number of flaring objects (green), objects with detected rotation periods (red), and objects with flares and rotation periods detected (orange) compared to those of the full sample analyzed here (blue). Bins separate the sample into M4, M5, M6, M7, M8, M9, L0, L1, and L2 spectral types.

3- Preliminary results:

1- For the **67 UCDs** analyzed so far, **we have detected both flares and periodic modulations in 14 objects (~ 21%), only flares in 13 objects (~ 19%) and only periodic modulations in 10 of them (~ 15%)**.

2- The values of the **detected periods range from 0.11 to 1.07 days**, while their **amplitudes span from ~ 1.4 to 18 mmag**. This is in agreement with the findings of previous studies (e.g. Miles-Páez et al. 2017).

3- A K-S test performed on the different distributions presented in Figure 2 indicates that all of them would represent the same population. Therefore, given the low number of stars studied in this contribution, it is not possible to identify any correlation. **It is necessary to compile a statistically significant sample of UCDs in order to analyze any trends in the data.**

Future prospects:

i) To perform a similar search for activity in the remaining UCDs of our sample.
ii) To determine if the results of previous studies between stellar activity and spectral type based on FGKM stars (Davenport 2016; Günther et al. 2020) are valid in a larger sample of UCDs and, hence, to provide a better understanding of the mechanism that would generate the observed intrinsic activity in these objects.

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References: Scargle, J. D. 1982, ApJ, 263, 835; Kirkpatrick et al. 1995, AJ, 109, 797; Ricker et al. 2015, JATIS, 1, 014003; Jenkins, J. M., Twicken, J. D., McCauliff, S., et al. 2016, SPIE Conference Series, Vol. 9913, The TESS science processing operations center, 99133E; Davenport 2016,ApJ, 829, 23; Bolmont et al. 2017, MNRAS, 464, 3728; McQuillan et al. 2013, MNRAS, 432, 1203; Miles-Páez et al. 2017, MNRAS, 472, 2297; Günther et al. 2020, AJ, 159, 60; Lightkurve Collaboration, Cardoso, J. V. d. M., Hedges, C., et al. 2018, Lightkurve: Kepler and TESS time series analysis in Python, Astrophysics Source Code Library.